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Report of the PSARC Herring Subcommittee Meeting September 3-5, 1997 and the Steering Committee Meeting September 24, 1997

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PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 97-4
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PACIFIC HERRING

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I. STEERING COMMITTEE REPORT

The Steering Committee met September 24, 1997 at the Pacific Biological Station to review the Herring Subcommittee report. The report was accepted, with the following comments and recommendations. The Steering Committee thanked the Subcommittee chair for a useful and well organized report.

Stock Status and Yield Recommendations

The five major herring stocks in B.C. are managed by a fixed harvest rate policy in conjunction with a Cutoff level. Cutoff levels are set at 25% of unfished average biomass. Yield recommendations are set at 20% of forecast annual biomass unless the forecast is close to or below Cutoff levels. Assessments of major stocks are conducted using both age-structured (ASM) and escapement (ESM) models.

Queen Charlotte Islands

The Steering Committee endorsed the recommended yield of 3,960 tonnes based on the assumption of average recruitment.

Prince Rupert District

The Steering Committee endorsed the recommended yield of 6,810 tonnes based on the assumption of average recruitment. Steering Committee notes and concurs that this recommended yield is based solely on the escapement model.

Central Coast

The Steering Committee endorsed the recommended yield of 8,910 tonnes based on the assumption of average recruitment.

Strait of Georgia

The Steering Committee endorsed the recommended yield of 14,530 tonnes based on the assumption of average recruitment.

West Coast Vancouver Island

The Steering committee endorsed the recommended yield of 8,010 tonnes. The Steering Committee accepted the Subcommittee recommendation of poor recruitment for this stock in 1998. The prediction of poor recruitment is based on a lower proportion of age 2+ fish observed in the offshore trawl survey relative to the 1996 survey, and warmer than average sea surface temperatures in 1995.

Minor Stocks

The Steering Committee endorsed the recommended yield of 170 tonnes for Area 27, and no surplus in Area 2W.

Comments on Working Papers

H97-1 Stock assessment for British Columbia herring in 1997 and forecasts of the potential catch in 1998.

Historically the choice of how estimates from the two assessment models were combined has differed among assessment regions, sometimes without sufficient explanation and documentation of the reasons why the estimate from one or the other model was thought to be questionable or less reliable. In general, the Steering Committee recommends that the process and rules for deciding the weighting of the estimates from the two models needs to be clarified and documented.

The Steering Committee accepted the working paper recommendations on revisions as well as the additional recommendations arising from Subcommittee discussion and which

are listed under General Subcommittee Recommendations. The Steering Committee emphasizes the need to portray, in future documents, uncertainty in the biomass estimates and associated risk in the projections given the harvest strategy and recruitment scenarios.

H97-2 Offshore herring distribution and 1998 recruitment forecast for the West Coast of Vancouver Island stock assessment region.

The Steering Committee accepted and endorsed the recommendations of the Subcommittee.

H97-3 Queen Charlotte Islands herring carrying capacity and sustainable harvest rates in different climate regimes.

The Steering Committee accepted and endorsed the recommendations of the Subcommittee.

H97-4 Analysis of juvenile surveys for recruitment predictions in Georgia Strait.

The Steering Committee accepted and endorsed the recommendations of the Subcommittee, and emphasizes the importance of continuing recruitment forecasting work.

H97-5 A retrospective analysis of escapement model performance using different adult survival rate estimates.

The Steering Committee accepted and endorsed the Subcommittee recommendations. The Steering Committee recommends that the analysis be expanded to other herring stock assessment regions.

H97-6 The effect of sampling time on the age-composition of herring test fishing samples.

The Steering Committee accepted the working paper recommendation, and further recommends that evaluation of whether there are significant differences in the age composition between catch samples and test fishery samples be carried out. This is a first step in addressing the problem with the age-structured model analysis for the Prince Rupert District.

H97-7 Sea surface temperature variations and timing and distribution of herring spawn in Georgia Strait.

The Steering Committee accepted and endorsed the recommendations of the Subcommittee.

H97-8 Age of sexual maturation and recruitment in Pacific herring: analyses of maturity based on oocyte diameter.

The Steering Committee accepted and endorsed the recommendations of the Subcommittee.

Comments on General Subcommittee Recommendations for 1997

The Steering Committee endorsed the general recommendations made by the Subcommittee with the following comments:

1. The Steering Committee Steering endorses the Subcommittee recommendation (#1) that understanding recruitment processes is a high priority. The Steering Committee notes that initial results using juvenile survey data in the Strait of Georgia (H97-04) are not encouraging, in contrast with the results on wVI (H97-02).

2. The Steering Committee recommends that explicit statements of uncertainty and risk of falling below cutoff biomass levels be incorporated into all herring assessment documents.

3. The Steering Committee shares Subcommittee concerns that a) variations in estimates of *M* vary substantially among regions, b) that estimates of *M* and stock productivity of the Central Coast stock are contradictory, and c) that the age-structured model performs poorly in the Prince Rupert district. Since the age-structured model is the principal assessment tool, the Steering Committee advises that resolution of these problems should continue to be a high priority.

II. HERRING SUBCOMMITTEE REPORT

1. PSARC Herring Subcommittee Objectives

The Subcommittee met on September 3-5, 1997 to review the status of herring stocks in 1997 and to forecast abundance and potential yield for 1998. The Subcommittee reviewed eight working papers (Appendix 1) and evaluated the impacts of pertinent assessment criteria (Appendices 3-7) in the formulation of advice to fisheries managers. The Subcommittee provided recommendations specific to the working papers in addition to general recommendations for further assessment work in support of management. Working paper titles, authors, and reviewers are listed in Appendix 1. A list of meeting participants is included as Appendix 2.

The Subcommittee evaluated a set of assessment indicators for each of the five major assessment regions. These criteria include:

- *Data quality*: catch data, spawn survey adequacy, consistency in age composition data;
- *Spawn and stock trends*: age-structured model and escapement model biomass estimates, spawn indices, in-season acoustic estimates;
- *Perception of stock status*: based on charter skipper and district staff field observations;
- *Recruitment trends*: age-structured and escapement model estimates, auxiliary survey data;
- *Cutoff*: minimum spawning biomass level for stock conservation;
- *Forecast abundance (run size)*: weighting for age-structured and escapement models, and evaluation of recruitment assumptions;
- *Additional information*: e.g. independent predictions of recruitment.

Subcommittee review of the assessment documents, in conjunction with the assessment criteria, was used to draw conclusions about the current biological status of the stocks and to provide yield recommendations for harvest in 1998.

2. Management Strategy

Major Stocks

Five major British Columbia herring stocks are currently managed by a fixed harvest rate strategy in conjunction with a fishing threshold or "Cutoff" level. Recommended yields are set at 20% of the forecast biomass for each of the major assessment regions, provided that the recommended yield does not reduce the biomass below the Cutoff. The 20% harvest rate is considered to represent a conservative level of removals given the biological productivity of the major herring stocks. Cutoff levels are set at 25% of the estimated unfished average biomass, as determined by simulation analyses. As the forecast abundance approaches the Cutoff, the recommended yield is the difference between the forecast abundance and the Cutoff. When the forecast falls below the Cutoff, a decision may be made to close the fishery to rebuild the stock. The objective of a Cutoff is to prevent relatively large fishery removals on stocks at low levels of abundance. This harvest strategy has been in place since 1983 prior to which the fishery was managed through a fixed escapement policy. A recent review (PSARC Working Paper H95-02) concluded that "*... the current management policy provides an adequate level of protection to conserve the stocks from a fishery collapse, and generates high long-term yields.*"

A summary of the performance of the forecasting procedure for 1997 herring fisheries is shown in Table 1, which compares the 1996 forecast of abundance in each stock assessment region to observed biomass in 1997 based on spawn surveys, catch, and model estimates. Note that with the exception of hailed catch, all numbers were rounded to the nearest 100 tonnes after the requisite calculations. Better than expected recruitment of the 1994 year class resulted in observed abundance greater than that forecast in 1996.

Table 1 Comparison of 1996 PSARC forecasts of 1997 herring abundance with estimates of 1997 observed biomass, catch, and escapement (tonnes). The recruitment assumption that generated the forecast biomass (poor, average, good) and the observed recruitment category are shown in brackets. All numbers rounded to the nearest 100 tonnes (except hailed catch).

Management Region	1996 Forecast of 1997 Biomass	1997 Observed Biomass	1997 Hailed Catch	1997 Escapement
Queen Charlotte Islands	11,000 (poor)	16,900 (average)	0	16,900
Prince Rupert	36,100 (average)	26,600 (average)	5,449	21,100
Central Coast	20,700 (poor)	33,700 (good)	3,153	30,600
Strait of Georgia	77,200 (average)	72,300 (good)	16,304	56,000
West Coast Vancouver sland	24,100 (poor)	40,300 (good)	6,559	33,800
Totals	169,100	189,800	31,465	158,400

Note: Although no catch was taken in the Queen Charlotte Islands region, 3 spawn on kelp operators used a maximum of 150 tonnes of herring to obtain their quota.

Minor Stocks

There are small or "minor" herring stocks that exist outside the five major stock assessment regions. The minor stocks are assessed opportunistically due to their inaccessibility, so the data series is neither continuous nor extensive. In its 1993 report, the PSARC Herring Subcommittee advised that there is no basis for fishing minor stocks above the 20% harvest rate established for the major stocks, and that DFO should also protect a minimum spawning biomass for the minor stocks.

At the 1994 PSARC Herring meeting, the Subcommittee recommended that because of incomplete historic data, minor stock harvests should be based on the estimated biomass of spawners in the previous season. Consequently, the Subcommittee recommended that the maximum biomass of fish harvested should not exceed 10% of the estimated previous season biomass. This recommended harvest rate for minor stocks is more conservative than the rate adopted for the major stocks; it is intended to compensate for the fact that minor stock survival and recruitment levels cannot be reliably predicted. The data do not allow accurate estimation of minor stock Cutoff levels. The Subcommittee advises that DFO should review biomass levels in light of available historic information prior to allocating minor stock harvests to clients. The Subcommittee also noted that some minor stocks exhibit large fluctuations in abundance and, therefore, there is no guarantee that allocated quotas for minor stocks are sustainable.

3. Catch Trends

Herring in British Columbia waters have supported some form of commercial fishery since 1877. Reliable records of place, date, and quantity caught are available since 1950. A fishery for a dry salted market from 1904-1934 (with catches up to 85,000 tonnes annually) was followed by a reduction fishery (1935-1967). During the reduction fishery catches were taken during the inshore spawning migrations from October to February. Very large catches (200,000 tonnes annually) in the early 1960s, in conjunction with a series of poor recruitments, led to the collapse of the reduction fishery and subsequent closure in 1968. Cessation of the intensive reduction fishery allowed a gradual recovery of stocks. The roe herring fishery began in 1972. Herring are now caught on or near the spawning grounds by both purse seines and gillnets.

In 1997, there were 252 roe herring seine licences and 1327 roe herring gillnet licenses. Of these licences, only 120 seine and 647 gillnet licenced vessels were eligible to fish. The difference can be attributed to inactivation of a substantial number of licences for double licenced roe fisheries, test fishing vessels, AFS purchases, and for spawn on kelp operations. Total roe landings have averaged 32,700 tonnes from 1993 to 1997. Prior to processing, the total landed value of the commercial roe herring catch in 1996 was $67 million, while the spawn on kelp fishery was valued at $31 million.

The roe fishery first came under quota regulations in 1983. Prior to this, guidelines of anticipated roe catches were provided. The PSARC recommended yield, actual quota in the roe fishery, and roe catches (thousands of tonnes) since 1983 are listed in Table 2.

Table 2: Stock biomass forecast, recommended yield, actual roe fishery quota, and roe catches (tonnes x 1000) since 1983.

		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997 [m]
QCI	Forecast[f]					15.3	12.1	13.7	35.3	23.2	18.1	17.7	12.4	7.7	6.7	11.0
	Rec. Yield[c]					2.2	0.0	2.7	7.1	4.6	3.6	3.5	1.0	0.0	0.0	0.3
	Roe Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5	4.7	3.3	2.1	0.0	0.0	0.0	0.0
	Roe Catch	8.1	5.0	6.3	3.6	2.0	0.3[a]	1.5	9.0[b]	7.0[b]	3.3[b]	2.7	0.3	0.0	0.0	0.0
PR	Forecast[f]					32.1	43.8	42.6	23.3	19.4	30.5	55.1	34.1	21.9	21.2	36.1
	Rec. Yield[c]					6.4	8.7	8.5	4.7	3.9	6.1	11.0	6.8	4.4	4.2	7.2
	Roe Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5	2.6	4.2	5.4	4.9	2.3	2.4	5.5
	Roe Catch	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.7	3.5	4.7	6.3	4.7	2.1	3.1	5.4
CC	Forecast[f]					23	23.8	48.5	43.2	38.2	37.7	70.1	69.8	54.4	25.8	20.7
	Rec. Yield[c]					4.6	4.8	9.7	8.6	7.6	7.5	14.0	14.0	10.9	5.2	3.1
	Roe Quota	*	6.6	4.1	2.3	3.4	3.7	7.8	7.4	6.2	5.3	7.8	10.3	8.5	3.2	1.4
	Roe Catch	5.6	7.2	5.2	3.3	3.6	4.5	9.4	8.4	8.9	7.3	10.5	11.9	10.0	4.3	3.1
SG	Forecast[f]					53.0	46.7	49.4	55.2	53.7	59.2	91.8	97.4	69.5	63.4	77.2
	Rec. Yield[c]					10.6	9.3	9.9	11.0	14.0	11.8	18.3	19.5	13.9	12.7	15.5
	Roe Quota	11.7	11.6	4.7	0.0	8.1	6.4	7.4	7.1	9.1	9.7	11.0	14.4	11.9	10.8	13.2
	Roe Catch	16.4	10.2	6.2	0.2[a]	9.1	7.5	8.4	8.1	10.5	11.6	13.1	16.7	12.1	13.6	15.1
WCVI	Forecast[f]					48.3	39.6	52.6	35.9	33.9	29.1		36.3	20.8	21.4	24.1
	Rec. Yield[c]					9.7	7.9	10.5	7.2	6.8	5.8	3.4[e]	7.3	2.0	2.0	4.8
	Roe Quota	4.5	4.5	0.0	0.0	9.4	8.1	10.3	7.2	6.7	2.9	2.7	5.3	1.3	0.9	3.7
	Roe Catch	8.7	6.7	0.2[a]	0.2[a]	15.9	9.7	13.3	9.8	8.6	3.4	5.6	6.4	1.5	0.8	6.6
Forecast	Total[f]					171.6	165.9	206.8	192.9	184.5	174.5		250.0	174.4	138.4	169.2
Rec. Yield	Total[c]					33.5	30.7	41.3	38.6	36.9	34.8	50.2	48.6	31.2	24.1	30.9
Coast	Roe Quota	28.0	31.3	18.8	12.5	27.7	25.8	33.7	30.7	29.3	25.4	29.0	34.9	24.0	17.3	23.8
Total	Roe Catch	38.8	32.6	24.4	15.6	36.7	29.9	41.1	40.0	38.5	30.3	38.2	40.0	25.7	21.8	30.2

* North of Cape Caution the quota for 1983 was 11.8;
[e] Charter boat removals;
[b] Includes removals from Area 2W;
[c] PSARC recommended yield, includes allocations to non-roe fisheries;
[d] catch data are preliminary fish slip information;
[e] Catch recommended not to exceed that for 1992.
[f] PSARC stock forecast used to derive recommended yield.
[m] hail data

4. Stock Status and Forecasts for Major Assessment Regions

Management Regions for Major Stocks

The stock assessment regions for major herring stocks are shown in Figure 1. For northern British Columbia, the stock assessment regions used for the 1997 assessments are the same as those used in previous years. In the Queen Charlotte Islands, the assessment region extends from Cumshewa Inlet in the north to Louscoone Inlet in the south. The Prince Rupert District stock assessment region includes all of Statistical Areas 3 to 5. The Central Coast assessment region encompasses Area 7, Kitasu Bay in Area 6, and Kwakshua Channel in Area 8. As recommended by the Herring PSARC Subcommittee in 1991, the Strait of Georgia is considered a single stock complex which includes Deepwater Bay and Okisollo Channel in Area 13 and all of Areas 14 to 19. In 1993, the northern (Area 25) and southern (Area 23/24) west coast of Vancouver Island regions were combined into a single assessment region (Areas 23 to 25).

Stock Assessment

Two analytic models, an age-structured model (ASM) and an escapement model (EM), are applied to each management region. An overall estimate of stock abundance in 1997 and forecast abundance for 1998 is obtained by combining the estimates from each model. In general, the two models are weighted equally unless there is information to suggest that one of the models does not provide consistent stock estimates (e.g. the age-structured model performs poorly for the Prince Rupert District, as described below). The potential recruitment of age 2+ fish to each stock is calculated as the top one-third, middle one-third and bottom one-third of the average of the recruitment estimates from the two models for the 1951-1997 time series, except in the Prince Rupert District where only the recruitment estimates from the escapement model are used. In the absence of additional information to forecast recruitment, the average recruitment forecast is used. Recruitment is added to the expected age 3+ and older abundance to obtain the forecast abundance. The recommended yield is 20% of the weighted, forecast abundance. If this yield would reduce the escapement biomass of a stock below the Cutoff, the recommended yield is calculated from the following equation:

$$\text{Yield} = \text{Weighted forecast} - \text{Cutoff}$$

Thus, progressively smaller fisheries are recommended when a stock approaches its Cutoff level. The Cutoff is calculated independently for each stock assessment region.

Recommended Coast-Wide Yield for 1998

The recruitment assumption, corresponding 1998 pre-fishery biomass forecast, and the recommended yield for each of the major stock regions are listed in Table 3. The spawning stock biomass trends based on the age-structured model (ASM) and escapement model (EM) are shown in Figure 2 and Figure 3. These trends were

interpreted in light of the assessment criteria listed in Appendices 3-7 for each management region to determine the recommended yield. Regional synopses are provided below. The Subcommittee notes that the total recommended yield of approximately 42,220 tonnes for 1998 is a 26 percent increase from the total recommended yield of 31,000 tonnes in 1997.

Table 3 Recommended Yield in 1998 for Major Herring Stocks

Assessment Region	Cutoff Biomass (tonnes)	Recruitment Assumption	Forecast Biomass (tonnes)	Recommended Yield (tonnes)
Queen Charlotte Islands	10,700	average	19,800	3,960
Prince Rupert District	12,100	average	34,000	6,810
Central Coast	17,600	average	44,500	8,910
Strait of Georgia	21,200	average	72,700	14,530
West Coast Vancouver Island	18,800	poor	40,100	8,010
Total			211,100	42,220

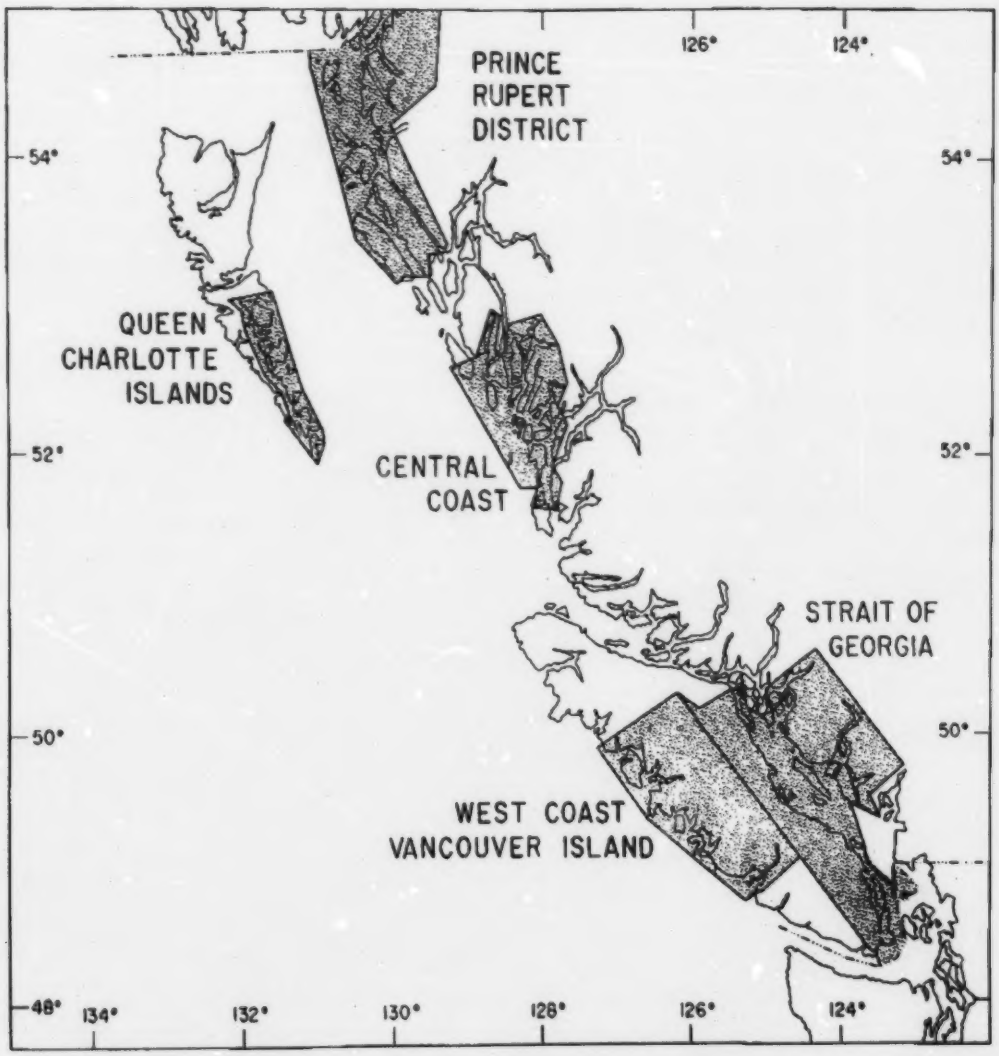

Figure 1 Herring stock assessment regions in British Columbia.

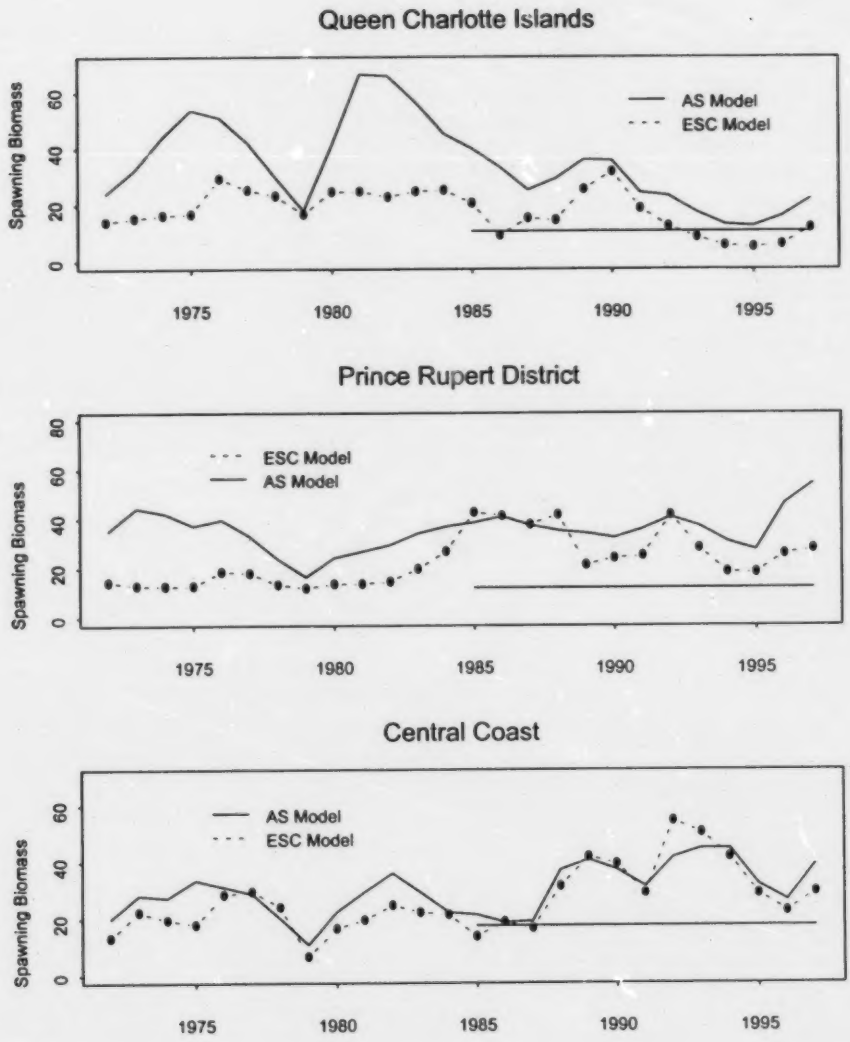

Figure 2 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1972-1997. The solid horizontal line indicates the Cutoff level.

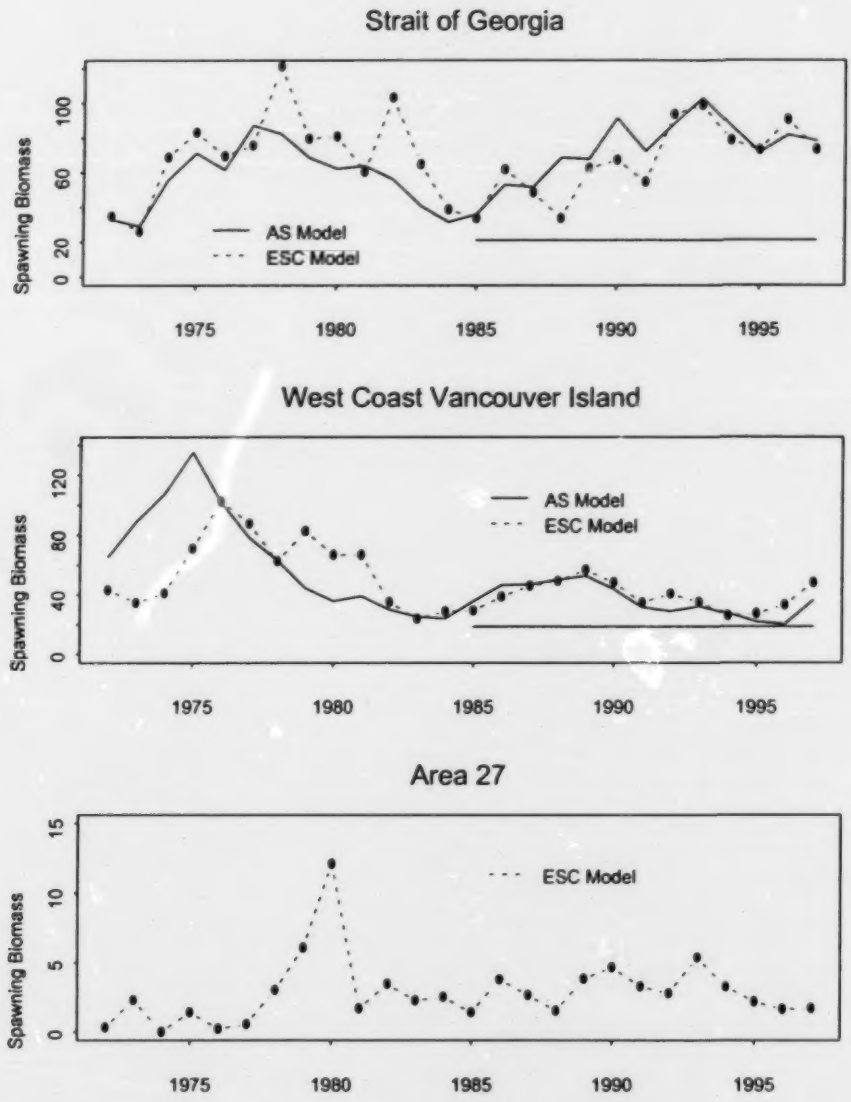

Figure 3 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions and Area 27, 1972-1997. The solid horizontal line indicates the Cutoff level.

Queen Charlotte Islands

Background

Landings during the reduction fishery period (1951-1968) were highly variable, targeting on a few strong year classes. The maximum catch taken during this period was over 77,000 tonnes, however, there were 6 years when catches were less than 1,000 tonnes. Catches have been more stable since the beginning of the roe fishery and have generally been in the range of 4,000 to 8,000 tonnes. The area was closed to roe herring fisheries in 1988 and 1989 due to stock concerns. The stock recovered after the closure but declined from 1990 to 1995. In response to the observed decline, annual roe fishery catches were reduced from 7800 tonnes in 1990 to 2700 tonnes in 1993. In 1994, the forecast return was close to Cutoff, and fishing was restricted to Food, Social and Ceremonial (FSC) harvest and spawn on kelp only. For 1995 and 1996, the forecast abundance was below Cutoff so fishing was limited to FSC harvest only. In 1997, FSC harvest was permitted, and three spawn and kelp operators used a maximum of 150 tonnes of herring to obtain their quota.

Assessment Criteria

Although commercial fisheries were absent in the Queen Charlotte Islands in 1997, in-season stock sampling and spawn assessment programs were carried out in a manner consistent with other assessment areas. In general, the level of biological sampling was adequate and all major spawns were covered by dive survey.

Both the age-structured and escapement models indicate a decline in abundance from 1990 to 1995, with increases in 1996 and 1997. The declining stock trend observed between 1990 and 1995 resulted from a series of poor recruitments. Increase in biomass since 1995 resulted from greater than average recruitment of the 1993 and 1994 years classes, which now constitute 33 and 26 percent of the stock, respectively.

The local fishery manager noted some improvement in the stock, while the charter skipper considered the Queen Charlotte Islands stock to show considerable improvement. Peak sounded tonnage increased to 12,500 tons in 1997 as compared to 5,800 tons in 1996.

In the absence of additional information, the Subcommittee adopted an average recruitment assumption in forecasting abundance for the Queen Charlotte Island stock in 1998. With a 50:50 weighting of the forecasts from the two models, the forecast prefishery biomass in 1998 is 19,800 tonnes. Application of the 20% harvest rate under the average recruitment scenario results in a recommended yield of 3,960 tonnes.

Prince Rupert

Background

During the period of the reduction fisheries, herring catches in the Prince Rupert District were generally in the range of 10,000 to 50,000 tonnes annually. Since the beginning of the roe herring fishery catches have averaged 5,000 tonnes and have not exceeded 9,000 tonnes. Since 1972, the fishery has been closed only in 1983. The area has supported substantial roe herring and spawn on kelp fisheries in recent years. However, there was no seine fishery carried out in the traditional location (Kitkatla Inlet) in 1996 or 1997 due to the low biomass of spawners in recent years.

The two assessment models show similar trends in abundance, however, the age-structured model estimates abundance at unreasonably high levels and only the escapement model is used in forecasting. Efforts to rationalise the model estimates continue, but further work is required. Stock abundance declined from a peak in 1992 to moderate levels in 1995, followed by an increase in 1996 and again in 1997. The stock has been supported in recent years by good 1988 and 1989 year classes which are now ending their life-span in the population. Increase in biomass observed in 1997 resulted from greater than average recruitment of the 1993 and 1994 years classes, which now constitute 56 and 18 percent of the stock, respectively.

Assessment Criteria

The quality of assessment data in 1997 was adequate and the trend in spawn indices supports abundance trends from the escapement model. Comments from fishery managers and charter skippers in 1997 indicate that returns to the northern portion of the assessment area (Big Bay) were good but that Area 5 is experiencing a decline (spawn in Kitkatla Inlet is the lowest observed since 1972).

Stock abundance estimates under all three recruitment assumptions are above the Cutoff. There was no information to suggest a recruitment assumption other than average. The forecast abundance based solely on the escapement model estimate under an average recruitment assumption is 34,000 tonnes. The recommended yield at a 20% harvest rate is 6,810 tonnes.

Central Coast

Background

Landings during the reduction fishery period (1950-1968) ranged to just over 44,000 tonnes and were generally around 10-35,000 tonnes. During the subsequent roe fishery period (1972-present), landings have averaged 7,145 tonnes and reached a maximum of 14,000 tonnes in 1978. No harvest was permitted in the Central Coast in 1979, but fisheries have occurred annually since that time. Harvests were approximately 10,000

tonnes from 1993 to 1995, then were reduced to 3,150 tonnes in 1997 in response to declining abundance. The 1994 year class comprised 57 percent of the stock in 1997.

Assessment Criteria

Abundance trends provided by the two assessment models agree closely and indicate a recent decline in stock abundance from a near historic high in the early 1990's. However, a good recruitment to the stock occurred in 1997 (1994 year class), following four years of poor to average recruitment. Consequently, both models indicated an increase in abundance from the low in 1996.

The quality of assessment data collected in 1997 is considered to be good, however, FSC catch remains unreported from the Central Coast region. The use of dive spawn surveys has been expanded to cover all spawns in the assessment area. The spawn indices are high and peak sounded tonnage in 1997 was 50,000 tons, well above the 1996 peak sounding of 30,000 tons. Charter skippers and local management staff both perceive healthy stocks with an abundance of smaller fish.

In the absence of additional information, the Subcommittee adopted an average recruitment assumption in forecasting stock abundance in 1998. The total forecast abundance using a 50:50 weighting of the two model estimates is 44,500 tonnes. The recommended yield at a 20% harvest rate is 8,910 tonnes.

Strait of Georgia

Background

Annual herring landings from the Strait of Georgia during the reduction fishery period (1951-1968) were less variable than from other areas of the coast. With the exception of the 1952/53 season when industry disputes curtailed the herring fishery, and the 1967/68 season when stocks had collapsed, landings ranged from 31,000 tonnes (1966/67) to 72,000 tonnes (1955/56). During the period of roe herring fisheries, catches have averaged 11,600 tonnes. The area was closed to roe herring fishing in 1986, after which time harvests have increased to a peak of 16,304 tonnes in 1997.

The high catches in the 1990's have been supported by near record high stock abundance in the Strait of Georgia. The two assessment models indicate a decline in abundance from about 90,000 tonnes in 1993 to 72,700 tonnes in 1997. The stock has been supported by above average recruitment in six of the last eight years, with the most recent recruiting year class (1994 year class) appearing to be of above average size. The recruiting 1994 year class contributed 52 percent of the stock in 1997.

Assessment Criteria

All the catch data were reported, and all major spawns were surveyed in 1997. Comments from fishery managers and charter skippers are consistent with the view that

stock abundance remains at high levels, particularly in Area 14 and Area 17N. The peak soundings estimated at 128,000 tons is the highest observed in recent years.

Projected stock abundance indicates that this stock remains well above Cutoff. In the absence of additional information, the Subcommittee adopted an assumption of average recruitment in the forecast for 1998. Using an equal weighting of the two model estimates, the forecast abundance in 1998 is 72,700 tonnes. The recommended yield in 1998 based on a 20% harvest rate is 14,530 tonnes.

West Coast Vancouver Island

Background

During the period of the reduction fishery, catches from the west coast of Vancouver Island reached nearly 70,000 tonnes in the 1958/59 season. In general, catches were in the range of 10,000 to 25,000 tonnes. During this period, annual harvests in the southern region (Area 23/24) exceeded harvests in the north (Area 25) for all but three years (51/52, 59/60, 62/63), often by large amounts. Since the roe fishery began in 1972, catches have been below the earlier levels, except from 1975 to 1978 when they ranged from 26,000 to 39,000 tonnes. In 1985 and 1986 the commercial fishery was closed along the entire west coast of Vancouver Island due to serious stock concerns. The stock subsequently rebuilt and the 1987 harvest of nearly 16,000 tonnes was the largest since 1979. However, the stock has experienced a declining trend since 1989; catches have averaged 5,400 tonnes since 1990 compared to an average harvest of 22,200 tonnes prior to 1980. Effort was restricted in 1995 and 1996 since forecast abundance was marginally above Cutoff in both years. In 1997, the forecast abundance was well above the Cutoff, and no effort restrictions were applied.

Assessment Criteria

The two assessment models indicated a declining abundance trend from 1989 to 1994, with a subsequent increase to moderate stock levels from 1995 to 1997. The decline resulted from a series of years with poor recruitment, interrupted by only one year of above average recruitment in the last eight years prior to 1997. Good recruitment was observed in 1997, when the recruiting year class (1994) accounted for 69 percent of the stock abundance. An increasing trend in spawn indices supports the recent positive abundance trend indicated by the escapement model.

The quality of assessment sampling and data collected was good in 1997, although Hesquiat Harbour spawn was underestimated due to adverse weather. Spawn length is at a recent high, although width declined due to the problems experienced sampling Hesquiat Harbour. Charter skippers and local management staff perceived that stock abundance had improved in 1997.

In developing the forecast for 1998, a recruitment forecast presented in H97-02 predicted poor recruitment in 1998 (1995 year class). This prediction is based on two pieces of

evidence: (1) an offshore trawl survey estimated that age 2+ herring (recruiting in 1998) will comprise about 33 percent of the spawning stock in 1998, as compared to an estimated 40 percent in 1997; and (2) an analysis of ocean temperatures, which were above the long term average during the first year of life of the recruiting year class. Retrospective analysis for this stock has indicated that there is a 58 percent chance that a year class born in a warm year will recruit poorly.

In consideration of the evidence cited above, the Subcommittee adopted a poor recruitment assumption. An equal weighting of the forecasts by the two models, under the assumption of poor recruitment, indicates a run size of 40,100 tonnes. The recommended yield based on a 20% harvest rate is 8,010 tonnes.

Minor Stocks

The recommended yield for Area 27 is 170 tonnes, computed as 10 percent of the assessed 1997 abundance of 1700 tonnes from the escapement model. No fishery is recommended in Area 2W due to the lack of spawn data, biological sampling for ages, and acoustic soundings from the area.

5. Stock Assessment Working Papers

This section presents a summary of each working paper and of the reviewer's comments. Subcommittee discussion is recorded, along with recommendations for revision of each working paper and directions for future analyses. General recommendations from the Subcommittee are listed in the following section.

H97-01: Stock assessment for British Columbia herring in 1997 and forecasts of the potential catch in 1998. Schweigert, Fort, and Tanasichuk.

Accepted with revisions

Summary

Stock assessments were presented from two analytical models which have been developed explicitly for British Columbia herring: (1) a modification of the escapement model described by Schweigert and Stocker (1988); and (2) a modification of the age-structured model described by Fournier and Archibald (1982). Both models reconstruct stock abundance for the period 1951-1997 and forecast pre-spawning abundance for the 1998 season. Forecasts of upcoming run size are based on the combination of estimates of surviving repeat spawners and newly recruited spawners which are presented as poor, average, and good, based on historical recruitment levels.

Reviewers' Comments

Reviewer A provided an extremely comprehensive review of the working paper that

focused on the provision of scientific catch advice that follows directly from the assessment. He commented that the assessment was in keeping with the high standard of analysis maintained by DFO assessment staff. Reviewer A suggested that the document would benefit from improved descriptions of the analysis including definition of terms, unit dimensionality, enhanced presentation and interpretation of model results, and fuller recommendations on the scientific catch advice that follows from the assessment. He proposed giving the catch recommendations a more direct focus in the document, in particular a table containing catch potential by assessment region, noting where Cutoff limits apply versus the 20% rule.

The process for producing Table 2.1 (escapement model results) was not evident to the reviewer who suggested that pages 6 through 9 were an artifact of past assessments. Reviewer A concluded that further explanation and data were required to clarify how these models are used and how the results are derived. The reviewer was complimentary of the spatio-temporal basis for the assessments, but suggested it would be useful to provide a discussion on similarities and differences among regions regarding the extent of total herring biomass.

Reviewer A judged the 16 pages of residual plots to be non-informative, given the brevity of explanatory text. The reviewer supported the inclusion of Fig. 5.3 and identified further opportunity for analysis. He suggested a sensitivity analysis of the impacts on spawning stock biomass of several alternative catch levels (above Cutoff) in anticipation of growth and recruitment gains, etc. Clarification was requested for the simulation basis for the cumulative probability plots.

Reviewer A provided an extensive list of detailed comments, some of which are mentioned here. The reviewer noted the striking difference in the estimates for natural mortality (ranging from 0.267 to 0.589) and the corresponding range in q (0.46 to 1.24). He questioned whether there were biological explanations for these differences and asked how these estimates compare with the assumptions of the escapement model parameters M1, M2, and M3.

Reviewer B concluded that the approach to herring assessment was reasonable and the presentation was fairly clear. The reviewer suggested that the document did not adequately portray the uncertainty in the biomass estimates and the associated risk in the projections under the harvest strategy and recruitment scenarios. He did note, however, that these concerns were unlikely to affect the results which show average to above average recruitment and biomass trends in most areas. It was not clear to the reviewer how uncertainty in the cumulative distribution plots was incorporated, and whether a decision maker could determine where the most likely estimates occurred or how flat the likelihood surface might be around the optimal biomass level. The reviewer requested clarification on the role of the poor, average, and good recruitment assumptions and whether there was any stochasticity assumed in the biomass projections. The reviewer asked how the apparent survival rates account for biases in partial recruitment, and age composition inconsistencies. The reviewer made several suggestions for improving the display of model diagnostics.

Subcommittee Discussion

The Subcommittee agreed that Reviewer A's comprehensive commentary could form the basis of several useful investigations in subsequent working papers. The poor spawn deposition data on the west coast of the Queen Charlotte Islands (Area 2W) was noted. Suggested revisions included altering plots as per reviewers comments. Subcommittee discussion focused on the range in estimates of M among stock assessment regions. Bias in the sampling data was discussed, however, it was pointed out that the age-structured model does use different selectivities for the different periods of the fishery in an attempt to compensate for bias. Nevertheless, the effect of systematic changes in the nature of the data over the period of the fishery could be examined by fitting the roe fishery period only, and contrasting the results to the fit obtained using the entire data series. It was suggested that the area around Vancouver be included in the stock assessment region.

Working Paper Recommendations

1. The Subcommittee accepted the paper with revision, as per reviewer's requests for clarification and suggestions for changes in the graphical analyses.

2. Additional recommendations which arose as a result of the review and discussion of H97-01 are listed under General Subcommittee Recommendations.

H97-02: Offshore herring distribution and 1998 recruitment forecast for the West Coast of Vancouver Island stock assessment region. Ware and Tanasichuk. **Accepted with revisions**

Summary

A multi-species mid-water trawl survey off the southwest coast of Vancouver Island (WCVI) was conducted between August 3 - 9, 1997. Twenty-five tows were made to assess the species composition, catch-per-unit of effort, diet, condition factor, size and age compositions of the dominant pelagic fish species in the region. The distribution of herring offshore in the WCVI stock assessment region has returned to a more normal state this year after the unusual summer last year (1996). The apparent abundance of herring was much higher than last year, and the schools were found in their usual concentration centres on 40-Mile Bank and Swiftsure Bank. There was also a good showing of herring along the outer edge of the continental shelf. Seven tows targeted on herring. Analysis of the length compositions suggests that the west coast of Vancouver Island herring spawning stock will contain 33 % age 2+ recruits in March 1998. Based on stock assessment model projections of the biomass of surviving repeat spawners, it is estimated that the strength of the recruiting 1995 year-class will be "poor" (about 7,300 tonnes). The long-term research program on the west coast of Vancouver indicates that

herring recruitment tends to improve when ocean temperatures are cool, and the summer biomass of migratory predators (like hake and mackerel) in the region is low.

Reviewers' Comments

The reviewers' noted the utility of the method for short term forecasting of herring recruitment, and concluded that the results and conclusions were efficiently presented. Both reviewers requested clarification on survey design, and questioned why acoustic data used to guide the selection of tow stations was not incorporated into the analysis. A more detailed explanation of the modal analysis for determining age classes was requested. Reviewer A suggested that bias in the estimation of the age 2+ biomass from the age-structured model (ASM) might be propagated to the computation of age 2+ biomass based on the survey results; he suggested removing the age 2+ biomass from the ASM biomass estimate prior to applying the survey proportions at age. Both reviewers commented that statements regarding the distribution of herring were not supported by data presented in the document. Reviewer A suggested that data and a discussion of relationships between herring recruitment, ocean temperature, and predators be included if these factors play an important role in interpreting the recruitment forecast.

Reviewer B concluded that the results are sufficiently documented and conclusions are appropriate, but commented on the small sample size (7 tows, 4 with significant catch per unit effort of herring). The reviewer questioned why tow 12 was not included in the analysis, despite the catch per unit effort of 48 kg/minute, which was the third highest in the survey. He suggested that the data for tow 12 be included to assess its influence on the analysis. The reviewer judged the discussion regarding mixing of Strait of Georgia and WCVI stocks to be weak, and questioned the current applicability of Tester's (1948) findings. He also suggested that the 1993/1994 data, although unusual, should be included in Table 2, given that data from other unusual years was not excluded.

Subcommittee Discussion

The Subcommittee discussed the potential for using the acoustic estimates from the survey to develop biomass-at-age estimates. However, it was pointed out that the acoustic information from the survey is qualitative (not echo integrated), and would be of limited utility. The Subcommittee considered the merits of incorporating quantitative acoustic data from a hake survey that nearly coincides with this survey. However, the distribution patterns of hake and herring are not similar, and there are significant technical and resource issues to overcome in the task of isolating the herring component of the acoustic data. Data were presented by the authors to illustrate the typical distribution of herring in July and August over the period from 1968 to 1993. The Subcommittee agreed that the sensitivity of the conclusions to the exclusion of tow 12 should be investigated. Tow 12 was originally excluded from the analysis on the basis that a small concentration of old fish was sampled, which was considered not to be representative of the population. Bias in the estimation of the age 2+ biomass was discussed. Retrospective analysis of the ASM biomass estimates has not revealed problems in the estimation of the 2+ age

class. The Subcommittee concurred that Tester's (1948) data may no longer be relevant, and concluded that the proportion of the Strait of Georgia stock migrating through Johnstone Strait was unknown. It was suggested that a comparison of survey age structure to the ASM age structure, or estimates of proportion at age derived from other sources, be presented. The Subcommittee noted the utility of the survey for forecasting the recruitment strength of the WCVI herring stock.

Working Paper Recommendations

1. The Subcommittee accepted the working paper subject to the suggested revisions. In particular, the implications of the tow 12 data on the recruitment analysis are to be evaluated and more information on the historical distribution of herring in the region is to be provided.

H97-03 Queen Charlotte Islands herring carrying capacity and sustainable harvest rates in different climate regimes. Ware. ** Accepted with revisions**

Summary

Over the last 44 years the pre-fishery biomass of the Queen Charlotte Islands (QCI) herring stock has averaged about 30,000 tonnes, and the catch about 8,000 tonnes. The productivity of this stock undergoes large changes in response to interannual and decadal time scale variations in spawner biomass. The surplus production curve suggests that the QCI stock, on average, is most productive at an average biomass of 25 to 30 thousand t. Since 1950, the average carrying capacity has been about 50 thousand tonnes. Recruitment accounts for most of the surplus production. The 1951 and 1977 year-classes were extraordinarily large. Multiple regression analysis indicates that the recruits per spawner shows a weak negative correlation with winter and spring sea surface temperatures, and a very weak positive correlation with the average winter (DJF) salinity at McInnes and Bonilla Islands. This is consistent with earlier findings. However, these correlations aren't very useful operationally because they don't explain much of the "density-independent" variability. It is not clear why the 1990, 1991 and 1992 year classes in this stock were so small. The failure of these year classes caused the stock biomass to decline below the Cutoff threshold (10,700 tonnes) and the closure of the roe herring fishery since 1994.

Reviewers' Comments

Reviewer A requested analyses to demonstrate structure in the environmental data consistent with climate regimes. He suggested that statistical evidence for structure in the environmental time series be provided. The reviewer concluded that the stock-recruit relationship may be biased given the measurement error in the dependent and independent variables. He suggested that there were insufficient model diagnostics to assess the strength of the density dependent relationship implied in the paper and

demonstrated that two uncorrelated random variables can result in a significant regression of the type presented in the paper. The regression of the surplus production/biomass ratio versus stock biomass may suffer from the same bias discussed above. The reviewer pointed out that the fitted relationship for these data was unlikely to be a simple linear function on the basis of Fig. 8. Reviewer A felt that the parameter bias problem defeated the stated claim of the paper and suggested that the paper be constrained to an examination of the effects of environment on recruitment, since density dependency is not estimable using a Ricker stock-recruitment formulation (bias in the slope due to measurement error is not separable from density dependence). Finally, the reviewer suggested that reference to sustainable harvest rate should be removed from the paper.

Reviewer B stated that critical data were not presented and requested more background information, details on the source of the weight data, an assessment of annual growth variability, details of computations relating environmental conditions to surplus production, and details of the fishery. The reviewer felt that the single most important point to address in revisions is to provide support for the estimate of instantaneous natural mortality (M), which is the keystone to the conclusions of the paper. The value of 0.46 used in the paper is strikingly high in the reviewer's experience, and he requested a description of the reliability of this estimate. The discussion of climatic variables requires data and analyses to be presented in order to support the conclusions. He pointed out that estimates of carrying capacity and sustainable harvest rates are also possible from the age-structured analyses and therefore requested clarification about how this analysis complements and relates to the age-structured model. The reviewer noted that model adequacy and sources of uncertainty were not adequately dealt with, and that this omission should be corrected in revisions. The reviewer questioned what caused the peak of initial biomass in the mid-1970s, when there were no outstanding year classes during that period.

Subcommittee Discussion

Analysis suggesting autocorrelation of the temperature series consistent with other temperature time series on the coast was presented. The existence of other research indicating climate regimes was noted. The magnitude of the statistical error of stock and recruit measurements in relation to the bias of parameter estimates was discussed. Simulation modeling reported in the primary literature suggests that if a sufficiently large range of stock sizes are observed, as is the case for this stock, then parameter bias may be reduced. The wide divergence in the estimated value of M among stock management areas was discussed by the Subcommittee. It was pointed out that M is confounded with the parameter q in the age-structured model and therefore cannot not be interpreted purely as an estimate of instantaneous natural mortality. For this working paper, the Subcommittee suggested that the available background material in support of M independent of the age-structured model be discussed in the revised document. The Subcommittee discussed the assumption of the Ricker curve, and proposed that the fit of the Ricker curve be compared to those obtained using other stock-recruit formulations. The possibility of determining surplus production directly from the Ricker curve, without

the requirement to fit a Schaeffer production model, was suggested. Considerable discussion ensued around the degree of confidence in recruitment estimates. The point was made that if there is difficulty determining recruitment of the large year classes (e.g. 1977) due to high uncertainty, then what is the level of confidence in the estimates of the smaller year classes? The lack of fit in the relationships between recruitment and environmental variables could be attributed to high uncertainty which reduces the ability to distinguish environmental relationships, even where such relationships exist. Lack of fit may also arise if the spawn surveys conducted in the early 1980s were incomplete in the Queen Charlotte Islands (QCI); in this case the escapement model may have underestimated the spawn. It was suggested that (1) large catches in the offshore reduction fishery may have consisted of a mixture of stocks rather than just the QCI stock, and (2) that offspring from spawners generated in QCI may not stay in the area. Diagnostic analyses from the age-structured model may be helpful in judging the likelihood of these explanations.

Working Paper Recommendations

1. The Subcommittee accepted the paper with revisions to address the reviewer's concerns, particularly in the area of surplus production and the provision of supporting evidence for the estimate of M. The discussion of the 1977 year class is to remain, but should be revised to identify the concerns raised about uncertainty.

H97-04 Analyses of juvenile surveys for recruitment predictions in Georgia Strait. Hay, McCarter and Schweigert. **Accepted with revisions**

Summary

Estimates of juvenile density were obtained from purse seine surveys from 1990-94 in the Strait of Georgia . The objective was to develop a predictive capability for estimating the relative size of the recruiting year class 1 or 2 years before it enters the fishery at age 2+. A reliable predictive capability, if it could be developed, would be useful for recommending yields for the fishery. The juveniles from the last year of the survey (1994) entered the fishery as age 2+ fish in 1997. The present year (1997) was the first opportunity to compare all years of the juvenile survey estimates with independent estimates of the 1994 year class derived from an age-structure model analyses. In some years, a large part of the fished population (20-50%) consists of herring that recruit in the same year. In previous PSARC meetings, participants have agreed that even a rough but accurate prediction into a few broad categories (i.e. poor, average, good) would be useful for setting future quotas. In this paper, the estimated juvenile density is compared with the number of age 2+ fish estimated independently 2-3 years later, from the age-structure analyses used for the annual assessments. The potential of this approach for future use by management is considered. Two main survey times were used in the juvenile surveys: late spring (June) and late summer (September). The June survey provides an estimate of the present year's (0+) cohort (age approx. 80 days), and the previous (1+) cohort

(about 450 days of age). The September survey provides a second estimate of the 0+ cohort (at about 150 days of age) but the previous (1+) cohort was no longer present, and presumably had migrated out of Georgia Strait. Five year classes were considered: 1990 to 1994. For the Strait of Georgia as a whole, there is no apparent relationship between juvenile density and the estimated numbers of age 2+ herring. Further, there was no correlation between year class size and previous juvenile abundance as measured on individual transect. This general conclusion holds for comparisons made for each survey time. There is, however, a lot of geographic variation in juvenile density. Therefore we also compared the two estimates for each transect. None were significant except one. One a single transect near Denman Island, in the September survey, there was positive covariance between juvenile surveys. As more than 20 tests of significance were made, such an occurrence may arise by chance alone. Therefore, the hypothesis that recruitment (defined as the number of age 2+ recruits from age-structure analyses) is positively related to juvenile density (as it was measured in these surveys) cannot be accepted. The reasons for the general poor correspondence between the two estimates (field surveys and age-structure analyses) are discussed, along with some assumptions about herring biology that may affect the results of juvenile surveys.

Reviewers' Comments

Reviewer A concluded that the paper did not contain information to evaluate the age 2+ and juvenile abundance estimation procedures. The reviewer recommended revising the paper to include (1) descriptions of study design, field procedures, and analytic techniques, and (2) a recommendations section. He suggested that consideration be given to expanding the document to evaluate forecasting methods. A major assumption of the paper was that juvenile abundance can be estimated precisely from field surveys, but no data or analyses supported this assumption. In support of producing a stand-alone document to the extent possible, the reviewer requested discussion on (1) the proportion of fish captured in the areas enclosed by the net, (2) the assumption of constant catchability among sites and years, (3) the adequacy of the sampling design used to determine set locations, and (4) whether two strata constitute a representative index of abundance for the Strait of Georgia. Further analysis was requested on how the sample data should be applied to the Strait of Georgia based on the habitat area expansion. The focus on transect 4 was criticized by the reviewer, as was the discussion of the stock concept for herring in the Strait of Georgia.

Reviewer B felt that the discussion of sources of error needed to be improved. The reviewer pointed out that significant attention is given to establishing that herring can be found throughout the study area. On this basis, he concluded that 5 sets on 10 transects does not adequately capture the spatial distribution of herring in the study area. After noting the concerns about changes in catchability of all ages and the vulnerability of age 0+ in June raised in the paper, the reviewer questioned the assumption that the survey protocol was followed exactly and therefore that departures did not contribute to the bias or imprecision. The reviewer questioned, given the caveats mentioned in the Discussion about failure in the survey design, how to design the sample survey adequately to measure changes in the abundance of juvenile herring.

Subcommittee Discussion

The Subcommittee agreed that this paper provides sufficient evidence to show that this particular survey design, for this particular stock assessment area is unlikely to provide an operationally useful estimate of the size of recruiting year classes. Although there is a suggestion in the data that it might be possible to obtain an index of recruitment from one of the transects (4), the Subcommittee was not comfortable with the idea of relying on a single transect to provide an estimate of year class strength. The Subcommittee noted that sampling and measurement errors inherent in the survey and in the age-structured model estimates of age 2+ (recruit) abundance increase the difficulty of finding a significant correlation, and of evaluating the adequacy of the current survey design. The Subcommittee recommended that this topic should be revisited in 1999 and 2000 when additional data from the most recent juvenile herring surveys conducted in 1996 and 1997 become available for evaluation. There was general discussion about the utility of juvenile fish surveys worldwide. The Subcommittee discussed the possibility of focusing the survey in the Hornby-Denman area, however, it was pointed out that other locations having high juvenile densities do not show an association with age 2+ abundance.

Working Paper Recommendations

1. The Subcommittee accepted the paper subject to revisions suggested in the reviews. In particular, the Subcommittee requested that key information from unpublished survey reports be extracted to meet the reviewers comments, and that estimates of among and within transect variability be included in the paper.

2. The Subcommittee recommended that the analysis be repeated to include the 1996 and 1997 survey data when the corresponding recruitment data become available in 1999 and year 2000.

3. The Subcommittee noted that estimates of juvenile herring abundance are available from the Strait of Georgia trawl survey conducted by the Ocean Sciences and Productivity Division, and suggested that these data be explored in subsequent analyses.

4. Because this survey appears unlikely to provide an operationally useful estimate of the size of recruiting year classes, the Subcommittee recommended that the Herring Stock Assessment Team discuss the merits of redirecting the recruitment forecasting work in the Strait of Georgia.

H97-05 A retrospective analysis of escapement model performance using different adult survival rate estimates. Tanasichuk and Schweigert. **
Accepted with revisions**

Summary

Test fishing data, catch data and spawning biomass estimates for the west coast Vancouver Island herring stock were used to compare how three different methods of estimating apparent adult survival rate affect the performance of the escapement stock assessment model. The first, the procedure currently used, included all test fishing data from 1972 to the present. The second excludes data from samples taken before 1980. These data were excluded because survival curves suggested size-selective test fishing before 1980. The first two procedures use running mean age-specific survival rates. The third method uses a regression which estimates age- and year- specific apparent adult survival rates based on the 1980-1996 data. The current procedure overestimates returning adult biomass by 28%. The second and third procedures underestimate biomass by 19 and 17% respectively. Residual analysis showed that the second and third methods underestimated biomass consistently. All procedures provided returning biomass estimates of acceptable accuracy.

Reviewers' Comments

Both reviewers judged the paper to be a reasonable and straightforward approach to (1) dealing with size selection in age composition early in the fishery, and (2) to incorporating external information in predicting survival rates. Reviewer A found the stability of the survival curves to be striking, and considered this to be a major finding of the paper. Both reviewers commented that the lack of information on the survival rate regressions precluded their review. Reviewer A noted that most of the current escapement model overestimate of 28% is in the first year (1982). The reviewer asked for clarification on whether a running mean of survival rates was used for each year. He noted the divergence of regression estimates from observed biomass estimates that occurs in recent years and requested some discussion of the departure. The reviewer questioned why only the current method correctly matched the spike in biomass in 1989. Reviewer A agreed with the conclusions and would like to see this analysis carried out for other stocks. Reviewer B requested clarification on whether apparent survivals are estimated separately for each year or as an average over all years.

Subcommittee Discussion

Subcommittee discussion focused on the data included for the analysis, and clarification was provided on how the moving averages were computed. Specific details on the stock areas included in the analysis was requested. The issue of bias introduced into the early roe fishery data by release of sets with small fish was discussed; it was suggested that the impacts of size selectivity through release of sets with small fish were negligible. The Subcommittee discussed whether results obtained using alternate methods fall within the range of uncertainty of the current estimates of survival. It was suggested that data prior

to 1980 is subject to bias and should be excluded from assessments. However, it was pointed out that the age-structured model uses different selectivities corresponding to the different periods in the fishery in an attempt to compensate for differential bias. The Prince Rupert stock was identified as a likely candidate for further application of this methodology, given the reliance on the escapement model in this region (the age-structured model performs poorly for the Prince Rupert stock). In recent years herring and hake distributions have spread out, an observation which may be related to the divergence in estimates noted by Reviewer A. The Subcommittee agreed that the three alternative approaches were comparable, and that the analysis serves as a useful diagnostic check for the escapement model.

Working Paper Recommendations

1. The Subcommittee accepted the working paper subject to revision. Specifically, the requested background information should be provided as noted by the reviewers.

2. The Subcommittee recommended that future analyses might examine the uncertainty of the current survival rates, assess the effect of deleting the 1982 data point on the biomass estimates, and expand the analysis to other assessment regions, notably the Prince Rupert stock.

H97-06 The effect of sampling time on the age-composition of herring test fishing samples. Tanasichuk. **Accepted with revisions**

Summary

Test fishing data collected since 1972 from all major stock assessment regions was used to determine if age compositions varied over time during the test fishing programs. This analysis was conducted to improve the performance of the age-structured model, particularly in the Prince Rupert District. Analysis consisted of fitting logistic regressions of the proportion of age 2+ herring (the usually dominant age-class) on sampling date. The proportion of age 2+ fish changed over time by at least 20% in 8% of the fishing season/assessment region groups. It is difficult to interpret these results. For the three major herring stocks above Vancouver Island, test fishing ends substantially before spawning ends so spawners are likely not sampled completely. Detailed analysis of the age composition data for Port Simpson/Big Bay and Kitkatla indicated that the age compositions, based on test fishing samples, are consistent between areas for only 3 of 18 years in this assessment region.

Reviewers' Comments

Reviewer A identified two major areas of concern with this paper: (1) it was not clear if results were statistically significant or biologically significant due to potentially large sample sizes, and (2) the report was unclear whether the "blocks of time" involve multiple

test sets pooled together. The reviewer commented that if the sample size is large, a negative Bayesian Information Criterion (BIC) may be observed even if there is a "statistically significant" change. He concluded that it is not clear what significance should be attached to the significant and not-significant differences reported from the log-linear analyses. The reviewer suggested that a log-linear model that included a multinomial response for age could be useful, providing that multiple sets representing different samples were included as a sub-sampling component to the model. A graph showing the proportion of "age-3" over time would be a useful first step in the analysis. The reviewer suggested that logistic regressions should be computed in preference to simple linear regressions on the empirical logits. He noted that since about 5% of the tests should be significant by chance alone, the 8% significant regressions may be false positives. Other significant results might be due to outliers, suggesting that the inclusion of model diagnostics would be of benefit. He suggested determining if there was a spatial or temporal pattern to the significant results.

Reviewer B commented that the objectives and relevance of the study were explained, but requested an expansion of the document to include information more pertinent to herring stock assessment. In the reviewer's opinion, model adequacy was not discussed and alternative approaches were not evaluated. The reviewer suggested examining 2 day blocks for the binning, and proposed that contingency tables might be a useful tool for these analyses. He requested more information on the BIC. The reviewer asked if it could be shown that cohort trends in the proportion at age data can be tracked over time. He also suggested that it would be useful to compare measures of location using other, more sensitive, statistical methods than those applied in the paper. The reviewer agreed with potential bias problems identified in the paper if the test fishery is unable to provide samples throughout spawning season in Port Simpson/Big Bay and Kitkatla.

Subcommittee Discussion

The Subcommittee noted that the effects of survey timing on age composition is an important topic, but a thorough and lucid description of the sampling data input to the age-structured model was required (all biological samples except those from the bait fishery were included in the age-structured model). The age-structured model relies on an estimate of the proportion at age in the catch, thus, it is important to evaluate whether there are significant differences in the age composition between catch samples and test fishery samples.

Working Paper Recommendations

1. The Subcommittee accepted the working paper with revisions as suggested by the reviewers.

H97-07 Sea surface temperature variations and the timing and distribution of herring spawn in Georgia Strait. Hay and McCarter. ** Accepted with revisions**

Summary

This paper examines changes in the spatial distribution and timing of herring spawn in the Strait of Georgia. In the last 20 years there has been a gradual concentration of herring spawn in some areas, mainly in the north, in the vicinity of Denman Island. In most other areas, spawn deposition has decreased. The variation of spawning time also has changed, with a reduction in the numbers of very early and late spawns. Mean spawning time, however, has not changed substantially and the changes are not related to the spawn index (or spawning biomass). Concurrent with these changes in spawn distribution and timing, sea-surface temperature has increased. Herring spawn data collected over the last 60 years were compared with sea-surface temperature data collected approximately over the same period. Within sub-sections of the Strait of Georgia, the temporal changes in the spawn index are either positively of negatively correlated to temperature. In the Denman Island and Qualicum areas, there is a positive correlation with temperature, but most other areas have a negative correlation.

The data and results are consistent with the hypothesis that temperature can affect the location of spawning. However, sea-surface temperature variation may not be the only explanation for changes in spawn distribution. If there is a functional relationship between spawn distribution and temperature, then a continued warming trend could lead to further changes in the distribution and timing of spawning.

Reviewers' Comments

Both reviewers remarked on the importance of the herring spawn data set, but concluded that there was insufficient support for a causal relationship between spawn timing/distribution and sea surface temperature. Reviewer A pointed out that changes attributed to temperature are confounded with time (e.g. the warming trend cannot be separated from changes in other plausible explanators such as pollution, herring biomass, or fishing effects which may have changed over the last 20 years). Both reviewers commented that univariate, linear statistical models were used to analyze observed relationships between spawning and temperature, even when the authors demonstrate the relationships are multivariate and non-linear. Reviewer A suggested comparing spawn attributes in the 1960s to those in the 1990s since similar temperatures were observed in both time periods. The incomplete treatment of the March-January temperature difference was criticized, as was the lack of comment on the reduction in variance of the temperature measurement beginning in the late 1960s. Similar comments applied to the behavior of the minimum and maximum day of year of spawning. The reviewer pointed out that the basis of the argument that spawn has shifted to the north west Strait of Georgia seemed to hinge on spawn increases at Denman Island, and decreases around Nanaimo. He suggested that the documentation for this apparent shift be improved. The reviewer suggested that while reduced spawning may occur in

response to warmer temperatures, other responses, such as more northerly or earlier spawning, or reduced survival of the spawn, may be plausible.

Reviewer B considered the fourfold peak in spawn from 1970 to 1985 and the reduction in variability of spawn timing in the last 10-15 years to be noteworthy observations. However, the reviewer suggested that the analyses were not well articulated, and require more specific hypotheses to enable significance testing and inference regarding causal relationships. The reviewer questioned whether Entrance Island temperatures are representative of those at localized spawning locations throughout the Strait of Georgia. The reviewer suggested that Fig. 15 simply reveals the range of temperatures over which spawning has been observed, rather than limits on spawning due to temperature, as suggested.

Subcommittee Discussion

The Subcommittee concurred with the general concerns expressed by the reviewers, but emphasized the importance of the observations of recent changes in spawn timing and distribution, particularly the concentration of spawning in the northwestern portion of the Strait of Georgia. The striking contraction in the range of within year spawn timing was noted and is worthy of more detailed analyses. The Subcommittee concluded that documentation of changes in spawn timing and distribution is an important first step in dealing with the topical issue of herring stock structure in the Strait of Georgia, and that this issue is a coast-wide concern. The Subcommittee requested that the paper be condensed to include only the observed changes in herring spawn patterns and, independently, the associated temperature trends. Furthermore, material should be added that identifies other plausible causes of the observed changes.

Working Paper Recommendations

1. The Subcommittee accepted the paper with revision. The Subcommittee endorsed the reviewers concerns and suggested that the paper be revised to document the variability of spawn in time and space. Reference to causal relationships should be removed from the paper, however, the existence of possible explanators (temperature series, salinity, biomass, fishing effects, etc.) should be raised as avenues for future analyses.

H97-08 Age of sexual maturation and recruitment in Pacific herring: analyses of maturity based on oocyte diameter. Hay and McCarter. ** Not accepted **

Working Paper Recommendations

1. The Subcommittee did not accept the working paper. The Subcommittee concurred with the reviewers that while the premise of the paper was plausible, the analysis did not provide a sound basis for the conclusions.

6. General Subcommittee Recommendations for 1997

The following general recommendations were developed as a result of review of the working papers and Subcommittee discussion:

1. Annual recruitment contributes a large component (30% to 50%) to the herring spawning biomass. Thus, increased understanding of herring recruitment is key to determining the productivity of stocks and to identifying harvest opportunities. The Subcommittee recommended that offshore recruitment forecasting work for the west coast Vancouver Island herring stock continue, and that the potential for recruitment forecasting for other major stocks be investigated.

2. Estimates of instantaneous natural mortality (M) vary among management regions (0.267 in the Central Coast to 0.589 in the Strait of Georgia). The Subcommittee recommended that this variation be investigated (1) to determine if biological explanations exist, and (2) to assess the likely impacts of confounding among parameters in the age-structured model.

3. The Subcommittee recommended that the effects of systematic changes in the nature of the data over the period of the fishery be examined by using the age-structured model to fit the roe fishery data only, and contrasting the results to the fit obtained when using the entire data series.

4. The Subcommittee recommended reviewing the Cutoff of 17,600 tonnes for the Central Coast management region, in light of the low value of instantaneous natural mortality estimated by the age-structured model and the relatively low long term productivity of the Central Coast stock.

5. Work to diagnose the poor performance of the age-structured model in the Prince Rupert District was conducted in 1996, but has not resolved the discrepancy with the escapement model estimates. The Subcommittee recommended continued efforts to identify the cause(s) of the difference and to rationalize the model predictions, if possible. This work should include a retrospective analysis of the escapement model performance.

6. The Subcommittee recommended that the analysis of variability in spawn timing and location in the Strait of Georgia be extended to assess the likely influence of environmental factors, changes in biomass, pollution, and fishing effects. The Subcommittee noted that this work has application coast wide.

7. The Subcommittee recommended that the analysis of juvenile survey data in the Strait of Georgia be repeated for the 1996 and 1997 surveys when surveyed year classes recruit in 1999 and year 2000.

8. The Subcommittee confirmed its support for the development of empirical estimates of variability for the spawn index. Understanding the variability in the spawn index is

essential to understanding its contribution to the uncertainty of biomass estimates and stock forecasts.

9. The Subcommittee recommended that efforts to improve compliance with the provision of catch data continue. The Subcommittee acknowledged the efforts of those organizations that compile and submit catch data. In particular, there has been noteworthy progress by a number of First Nations fisheries programs.

10. The Subcommittee recommended that recent gains in spawn survey coverage outside the major stock assessment regions be maintained, and that quality control auditing by DFO staff continue. The Subcommittee noted that no resources are currently identified for spawn surveys outside the major stock assessment areas.

11. The Subcommittee recommended that the Areas 28 and 29 be included as part of the Strait of Georgia stock assessment region in the absence of data indicating a separate stock.

7. Progress on Subcommittee Recommendations for 1996

1. In general, there has been improvement in the provision of catch data to the Department relative to previous years. Currently, only the status of FSC (food, social, ceremonial) removals in the Central Coast management region remains unknown.

2. In 1997, spawn survey coverage was increased in areas outside the major stock assessment region of the Central Coast. Spawn information in peripheral areas is critical to increased understanding of herring stock structure, the evaluation of potential habitat degradation, assessing the impacts of nearshore development, the land claim process, and identifying opportunities for spawn on kelp harvest and bait fisheries. Spawn surveys in the Johnson Strait area are being reviewed to diagnose whether the lack of spawn observed is due to inadequate survey coverage or due to a true absence of spawn. In season auditing of contractors by DFO staff revealed no serious problems in the conduct of spawn surveys in 1997. The Subcommittee noted, however, that recent gains in spawn survey coverage may be lost if secure funding is not identified.

3. The Subcommittee considered working papers that evaluated the effect of environmental factors on west coast Vancouver Island herring recruitment and surplus production (H97-02), and examined the relationship between recruitment and environmental factors for the Queen Charlotte Island region (H97-03). The Subcommittee noted the utility of the forecasting procedures for the west coast Vancouver Island.

4. Based on the data collected to date and the analysis provided in H97-04, the juvenile survey data from the Strait of Georgia are unlikely to provide an operationally useful estimate of the size of recruiting year classes.

5. The Subcommittee identified the need for work to quantify the variability of the spawn index (the egg index) via a bootstrap analysis. Early results of this were discouraging and no working paper was tabled.

6. The Subcommittee requested an examination of biological sampling focused on the timing and locations of research and catch samples relative to the execution of commercial fisheries and spawn deposition. A working paper (H97-06) was tabled that suggested the age composition can change over the course of sampling, and that test fishing often terminated prior to the end of spawning.

7. A retrospective analysis was conducted using three competing methods for estimating survival for the west coast Vancouver Island stock (H97-05). The sensitivity of abundance forecasts derived from the escapement model was examined; the three methods were comparable and all provided acceptable performance.

8. Partnerships with Clients

In 1995, a meeting was convened with client groups immediately following the PSARC review of herring stock assessments. This meeting, termed a "Biological Review", had the objective of fostering improved partnerships with client groups which had expressed displeasure with being excluded from the PSARC process. Science Branch staff presented herring stock assessments and forecasts for the subsequent year; discussion was confined to the biological basis for these assessments. Unfortunately, the meeting was poorly attended by clients in 1995. As a result, the Biological Review was not held in 1996. Prior to the 1997 fishery, managers met with interested processors, fishers, and First Nations organizations to present assessment and management information. External participants from industry and First Nations attended the PSARC Herring meeting in 1997 to assist in reviewing the assessment documents.

Stock status reports have been completed for each of the five major herring stocks and will be updated to reflect the 1997 fishery and assessment. The Subcommittee continues to consider innovative strategies, such as video taped reviews for cable television, to disseminate information to the general public.

9. Other Business

Stock Status Reports

Stock Status Reports for the five major herring stocks were distributed for comment at the meeting. The reports will be updated to reflect the 1997 fishery and assessment. The Stock Status Reports will be available for general release pending approval.

Environmental Indices

As requested by the PSARC Ad hoc Subcommittee meeting on Marine Environmental and Habitat Issues (10-12 March 1997), the Subcommittee was advised of the importance of including environmental indices in stock assessment analyses. Four of the working papers reviewed by the Herring Subcommittee explicitly attempted to incorporate environmental indices for the 1997 stock assessment. The Subcommittee was advised of the request to identify and compile time series of stock indices, stock reconstructions, and anomalies between data sources to be utilized by researchers working with environmental data.

Publication of Working Papers

Since PSARC documents may not be widely available after approval, the potential for publishing working papers as a collected volume (e.g. Can. Tech. Rep. Fish. Aquat. Sci.) was discussed. An alternative avenue may be a western counterpart to the Canadian Atlantic Research Document Series used to publish east coast assessment documents.

Appendix 1 - PSARC Herring Working Papers for 1997

Number	Title	Author(s)	Reviewers
H97-1	Stock assessment for British Columbia herring in 1997 and forecasts of the potential catch in 1998.	Schweigert, J. Fort, C. Tanasichuk, R.	Lane, D. Sullivan, P.
H97-2	Offshore herring distribution and the 1998 recruitment forecast for the west coast of Vancouver Island stock assessment region.	Ware, D. Tanasichuk, R.	Perry, I. Claytor, R.
H97-3	Queen Charlotte Islands herring stock carrying capacity and sustainable harvest rates in different climate regimes.	Ware, D.	Cass, A. Nielson, J.
H97-4	Analysis of juvenile surveys for recruitment predictions in Georgia Strait.	Hay, D. McCarter, B. Schweigert, J.	Schubert, N. Smith, S.
H97-5	A retrospective analysis of escapement model performance using different adult survival rate estimates.	Tanasichuk, R. Schweigert, J.	Funk, F. Powles, H.
H97-6	The effect of sampling time on the age composition of herring test fishing samples.	Tanasichuk, R.	Fargo, J. Schwarz, C.
H97-7	Sea surface temperature variation and the timing and distribution of herring spawning in Georgia Strait	Hay, D. McCarter, B.	Mulligan, T. Stanley, R.
H97-8	Age of sexual maturation and recruitment in Pacific herring: analyses of maturity based on oocyte diameter.	Hay, D. McCarter, B.	Holtby, B. Wheeler, J.

Appendix 2 List of Participants for 1997 PSARC Herring Meeting

Name	Association
D. Chalmers	DFO, South Coast Division
C. Fort	DFO, Stock Assessment Division
L. Gordon	DFO, Port Alberni D/O
D. Hall	Nuu-chah-nulth Tribal Council
L. Hamer	DFO, South Coast Division
B. Harrower	MAFF
D. Hay	DFO, Stock Assessment Division
R. Jones	Haida Fisheries Program
R. Kronlund (Subcommittee Chair)	DFO, Stock Assessment Division
B. McCarter	DFO, Stock Assessment Division
G. McEachen	DFO, Comox S/D
S. McFarlane	DFO, Stock Assessment Division
B. Melan	Fishing Vessel Owners Association
L. Richards	DFO, Stock Assessment Division
E. Safarik	Herring Conservation and Research Society
J. Schweigert	DFO, Stock Assessment Division
M. Stocker (PSARC Chair)	DFO, Science Branch
R. Tanasichuk	DFO, Stock Assessment Division
G. Thomas	DFO, South Coast Division
D. Ware	DFO, Stock Assessment Division
I. Winther	DFO, North Coast/Prince Rupert

Appendix 3 Criteria for assessment of stock status in 1997: Queen Charlotte Islands

Criteria	Status
1. Data quality:	
(a) all catch reported	Yes
(b) all spawn surveyed	Yes
(c) consistent age composition	Higher proportion of age 1+ fish in Louscoone/Skincuttle
2. Spawn and stock trends:	
(a) age-structured model	Increasing from recent low in 1995
(b) escapement model	Increasing from recent low in 1995
(c) spawn indices	Length increasing from 1995 low, width decreasing
(d) in-season echo-soundings	12,500 tons peak soundings
(e) consistent trend information	Yes
3. Perception of stock status:	
(a) charter skippers comments	Considerable improvement, good recruitment
(b) management staff	Some improvement
4. Recruitment trends:	
(a) age-structured model	Poor from 1992 to 1995, good in 1996, average in 1997
(b) escapement model	Not considered
5. Cutoff	10,700 tonnes
6. Forecast weighted run size:	
(a) weighting (ASM:ESM)	50:50
(b) recruitment assumption:	weighted forecast stock size:
• poor	• 17,500 tonnes
• **average**	• **19,800 tonnes**
• good	• 25,800 tonnes
7. Additional information	Cumulative probability plots indicate all forecasts above Cutoff
8. Yield Recommendation	3,960 tonnes (average recruitment assumption)

Appendix 4 Criteria for assessment of stock status in 1997: Prince Rupert District

Criteria	Status
1. Data quality:	
(a) all catch reported	Yes
(b) all spawn surveyed	Yes
(c) consistent age composition	Section 42 60% age 3+, Section 52 40% age 3+
2. Spawn and stock trends:	
(a) age-structured model	Not considered
(b) escapement model	Increasing since 1995
(c) spawn indices	Large increase in 1996, sustained in 1997
(d) in-season echo-soundings	20,000 tons Area 3&4, 3,000 tons Area 5
(e) consistent trend information	Yes
3. Perception of stock status:	
(a) charter skippers comments	Port Simpson/Big Bay good; Area 5 declining
(b) management staff	Port Simpson/Big Bay spawn good and many small fish, Kitkatla poor
4. Recruitment trends:	
(a) age-structured model	Not considered
(b) escapement model	Poor in 1995, good in 1996, average in 1997
5. Cutoff	12,100 tonnes
6. Forecast weighted run size:	
(a) weighting (ASM:ESM)	0:100
(b) recruitment assumption:	forecast stock size:
• poor	• 30,900 tonnes
• **average**	• **34,000 tonnes**
• good	• 44,900 tonnes
7. Additional information	Cumulative probability plots indicate all forecasts above Cutoff, spawn in Kitkatla lowest since 1972
8. Yield Recommendation	6,810 tonnes (average recruitment assumption)

Appendix 5 Criteria for assessment of stock status in 1997: Central Coast

Criteria	Status
1. Data quality:	
(a) all catch reported	No, Food, Social and Ceremonial catch unreported to date
(b) all spawn surveyed	Yes
(c) consistent age composition	Yes
2. Spawn and stock trends:	
(a) age-structured model	Increase from recent low in 1996
(b) escapement model	Increase from recent low in 1996
(c) spawn indices	High
(d) in-season echo-soundings	50,000 tons peak soundings, highest on record
(e) consistent trend information	Yes
3. Perception of stock status:	
(a) charter skippers comments	Stocks healthy, an abundance of smaller fish.
(b) management staff	Stocks healthy, an abundance of smaller fish
4. Recruitment trends:	
(a) age-structured model	Poor in 1995, average in 1996, good in 1997
(b) escapement model	Not considered
5. Cutoff	17,600 tonnes
6. Forecast weighted run size:	
(a) weighting (ASM:ESM)	50:50
(b) recruitment assumption:	weighted forecast stock size:
• poor	• 41,800 tonnes
• **average**	• **44,500 tonnes**
• good	• 54,700 tonnes
7. Additional information	Cumulative probability plots indicate all forecasts above Cutoff
8. Yield Recommendation	8,910 tonnes (average recruitment assumption)

Appendix 6 - Criteria for assessment of stock status in 1997: Strait of Georgia

Criteria	Status
1. Data quality:	
(a) all catch reported	Yes
(b) all spawn surveyed	Yes
(c) consistent age composition	40% age 1+ Yellow Point, 51% age 2+ in Area 14
2. Spawn and stock trends:	
(a) age-structured model	Near historic highs
(b) escapement model	Near historic highs
(c) spawn indices	Declining, near recent highs
(d) in-season echo-soundings	128,000 tons peak soundings
(e) consistent trend information	Yes
3. Perception of stock status:	
(a) charter skippers comments	Very healthy stocks, impressed by Area 17 stock and spawn
(b) management staff	Healthy stocks
4. Recruitment trends:	
(a) age-structured model	Poor in 1995 average in 1996, good in 1997
(b) escapement model	Not considered
5. Cutoff	21,200 tonnes
6. Forecast weighted run size:	
(a) weighting (ASM:ESM)	50:50
(b) recruitment assumption:	weighted forecast stock size:
• poor	• 58,100 tonnes
• **average**	• **72,700 tonnes**
• good	• 92,700 tonnes
7. Additional information	Cumulative probability plots indicate all forecasts above Cutoff
8. Yield Recommendation	14,530 tonnes (average recruitment assumption)

Appendix 7 Criteria for assessment of stock status in 1997: West Coast Vancouver Island

	Criteria	Status
1.	Data quality:	
	(a) all catch reported	Yes
	(b) all spawn surveyed	Hesquiat Harbour spawn underestimated
	(c) consistent age composition	Yes
2.	Spawn and stock trends:	
	(a) age-structured model	Increase in 1997
	(b) escapement model	Increase in 1997
	(c) spawn indices	Length at recent high, width declined due to unsurveyed Hesquiat spawn
	(d) in-season echo-soundings	24,000-29,000 tons peak soundings
	(e) consistent trend information	Yes
3.	Perception of stock status:	
	(a) charter skippers comments	Area improving
	(b) management staff	Area improving
4.	Recruitment trends:	
	(a) age-structured model	Poor in 1994 and 1996, good in 1997
	(b) escapement model	Not considered
5.	Cutoff	18,800 tonnes
6.	Forecast weighted run size:	
	(a) weighting (ASM:ESM)	50:50
	(b) recruitment assumption:	weighted forecast stock size:
	• **poor**	• **40,100 tonnes**
	• average	• 46,500 tonnes
	• good	• 62,400 tonnes
7.	Additional information	Cumulative probability plots indicate all forecasts above Cutoff, offshore survey forecasts poor recruitment (H97-02)
8.	Yield Recommendation	8,010 tonnes (poor recruitment assumption)